central cutter and with two forward- and two backward-acting cutters, so that the auger shall cut both in its forward and backward motions.

In using this machine the operations are as follows: When the machine is brought up to the face of the coal or mineral to be operated upon, the cutter-bar drill *a* is set in motion, and while revolving it is fed into the face of the mineral by an automatic or hand-feed motion, which latter is shown on the drawings at Figs. 1ª and 23, and consists of a circular rack a^{10}, as shown at Figs. 1ª and 6, or a screw rack a^{10}, as shown at Fig. 23, which may be either cast or cut on the cutter-bar *a*, or otherwise combined therewith, a pinion *d* being arranged to gear into such rack.

As shown in Fig. 1ª, the said pinion *d* has its axis d^1 formed square to receive a lever-handle, by which it can be rotated, but, if desired, it may be fitted with a ratchet-wheel and driving-pawl. The said pinion *d* is carried by a casting d^2 pivotted at d^3 to the cutter-bar bearing d^4, and such casting d^2 is fixed in working position by a bolt d^5 passing through a segmental slot d^6, so that by loosening said bolt the casting d^2 can be turned on its pivot d^3, and the pinion *d* removed out of gear with the rack a^{10}.

When the cutter-bar drill *a* has entered to the depth required it is locked by the blocks *e* of the reciprocating motion gear, and all strain or action taken off the feed-gear by removing the pinion *d* out of gear with the rack a^{10}. The reciprocating motion is obtained preferably by forming on the sleeve *b* a worm-thread b^3, into which gears a worm-wheel *f*, carrying on its gudgeon f^1 two crank-pins f^2, fitting into blocks f^3, which actuate two rocking-levers f^4. Fitting round the circular rack a^{10}, and embracing several rings of said rack, is the thrust-block *e*, which is in halves, each half being coupled by a right- and left-hand screw e^1. These divided thrust-blocks *e* are connected to connecting-rods e^2, operated by the rocking-levers f^4, which impart the reciprocating motion of the latter to the cutter-bar drill *a* when the thrust-block *e* and drill *a* are connected.

Instead of the divided thrust-block *e*, as described above, acting in connection with the rack a^{10}, it may act between two or more shoulders on the sleeve, and give motion to the cutter-bar drill through the intervention of the sleeve *b*, the sleeve in such case being capable of sliding through the bevelled wheel b^2.

The machine is traversed forward along the face of the mineral by means of a snatch-block and a hauling-drum *g* mounted on an axis g^1 passing through the axis of the switch *h*, the rope being wound on to the drum and passing around a snatch-block and then to a fixture on the machine, or such rope may pass direct from the hauling-drum to any fixture.

Instead of using the hauling-drum a chain-wheel and chain may be employed, but when working down hill or on a level, cranks g^2 fixed on the axis g^1 are used, and connecting-rods g^3 connect such cranks with the driving-wheels g^4. The casing *h* of the switch is fitted to the front trunk A^1 of the motor A, and the hauling-drum *g*, or chain-wheel and cranks g^2 and rods g^3, are driven from the motor-shaft *c* by means of worm- and spur-gearing and friction-cones as shown in Fig. 22, and described in my English specification, No. 1,036, of the year 1872. The cutter-bar drill at the same time revolves, thus cutting away the coal in front of it, while its reciprocating motion assists in breaking up the coal and dislodging any lumps of pyrites that may be met with.

In order that the coal or mineral may be nicked on end to expedite the breaking-down of the mineral when undercut, the cutter-bar drill *a*, with its sleeve *b* and feed-gear, are carried by a separate casting B, carrying the bearing B^1 for the motor-shaft *c*, and which is so arranged as to make a whole or partial revolution round the motor-shaft by means of a worm *i* and worm-wheel i^1. (See Figs. 1, 1a, 2, 22, 23, 24, and 25.) By this arrangement also the machine is enabled to cut either right or left hand, thus dispensing with a costly left-hand cutting arrangement, as required in other machines now in use.

In this class of machine, the vibration, when at work, is very great, and I reduce this greatly by fixing or constructing the journals to carry the cutter-bar drill *a* at an angle of about 80°, with the rails in the direction in which the machine is moving, as represented at Figs. 1ª, 23, and 24, thereby causing the machine to hold itself well up to its work.

I also provide the machine with rail slide-blocks *x* (see Fig. 3) in addition to the usual wheels g^4, which blocks, when at work, are let down onto the rails, and, by their large bearing-surface, give the machine more stability and greater steadiness.

The wheels g^4 and blocks *x* are provided with screws g^5 similar to those patented by me in England on the 3rd April, 1872, No. 1,036, for raising and lowering same, and so varying the height or angle of the cut, except that the screws are right and left threaded, so that when acting, to lower the block, they shall raise the wheels, and *vice versâ*; separate screws, however, may be employed.

One set or pair of wheels g^4 and blocks *x*, and their respective raising-screws g^5, are attached to a separate casting C (see Figs. 1 and 22), made free to revolve, or partly so, round the outer portion of the leading trunk A^1 of the motor A, and are thus capable of adapting themselves to any unevenness of the rails on which the machine works; another set or pair of wheels g^4 and blocks *x*, with their respective screws g^5, are fixed or coupled to the back trunk A^2 of the motor A. (See Figs. 23 and 24.)

To take out the cuttings made by the cutter-bar drill I use a cleaning-bar *j* (see Fig. 24), preferably U-shaped in section, set at an acute angle to and behind the cutter-bar drill *a*, and fixed to the machine by suitable means when at work. The cuttings are caused, by the forward motion of the machine, to slide along the face of this cleaning-bar, and to be deposited between or at the side of the rails as the machine proceeds.

I remove irregularities from the face of the mineral, and from the bottom, by means of a fixed cutter *k*, shown at Fig. 1ª, and by dotted lines at Fig. 4 and at Fig. 26, attached to the front journal casting B of the cutter-bar drill *a*, the said fixed cutter *k* at the same time forming a cover for the thrust-block gear. This fixed cutter *k* has a cutting-edge k^1 to clear the bottom, and an inclined cutter-edge k^2 to remove projection on the face of the mineral sufficiently high to clear the cutter-bar bearing.